

## **Solid Waste Management in Bamenda III Municipality, Cameroon: Challenges and Implications for Sustainable Waste Management**

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### **ABSTRACT**

*This study examined solid waste management in Bamenda III Municipality, Cameroon. A survey was conducted and structured questionnaires were administered to 100 households by systematic sampling—secondary data comprised a review of literature from published and unpublished sources. Descriptive statistics were used for data analysis. Findings reveal that; dependence on government authorities (53%), finance and other environmental factors (61%), limited equipment (60%), and poor household waste segregation practices (66%), were some of the key drivers. The results on measures to improve sustainable solid waste management show that participants strongly agree that massive sensitization (63%), awareness of inhabitants on waste management (61%), and providing waste management equipment (61%) were some of the measures. Educating the population on modern waste recycling techniques and involving every community member in waste management is a sustainable measure to ameliorate these challenges in the Municipality.*

**Keywords:** Bamenda III Municipality, Solid Waste, Waste Management, Challenges.

### **1. Introduction**

Waste production in a Municipality results from numerous human activities. In a global scenario, about 7–9 billion tonnes (Wilson and Velis, 2015), of waste are produced yearly. Municipal Solid Waste (MSW) (Bhatti *et al.*, 2021) is waste generated from improper disposal of household garbage (Khan *et al.*, 2022) and includes waste generated from commercial and industrial

activities (Cárcamo and Peñabaena-Niebles, 2022). MSW amounts to about 2 billion tonnes (Chen *et al.*, 2020), of waste generated in 2016. Urbanized Municipalities are usually accompanied by many economic activities (Douti *et al.*, 2017; Gui *et al.*, 2019), resulting in huge quantities of MSW generation (Pathak *et al.*, 2020), compared to less urbanized Municipalities. Urbanizing areas tend to sustain urban growth with increased infrastructural development (Swapan *et al.*, 2017). This explains the need for every Municipality access to proper Waste Management (WM) infrastructures (Serge and Simatele, 2020), for MSW disposal and treatment. Waste generation in our Municipalities has increased as economic development advances (Rajmohan *et al.*, 2021). The rise in MSW can be likened to population growth and rapid urban growth, as well as growth in economic development.

Waste generation in Municipalities has increased so much that access to trash canned, waste collection and disposal (Abdel-Shafy and Mansour, 2018), and transformation of waste has remained a problem. The World Commission on Environment and Development (WCED, 1987) emphasized the need for a healthy environment as unhealthy human environments constitute areas of ecological disorder manifested through disease prevalence, and pollution among others (WCED, 1987). Starting from this time to the Rio 1992 Conference on Environment and Development (Atapattu, 2018), debates on environmental sustainability were initiated. Many countries have been able to enact ecological laws to govern their specific environments together with the ratification of other international environmental conventions (Ite *et al.*, 2016), relating to environmental protection (Juríčková *et al.*, 2020) and management. These laws/conventions provide the rules guiding waste collection, storage, transportation (Karim and Lee, 2023) and disposal of waste (Albrecht *et al.*, 2022).

In Sub-Saharan Africa (SSA) (Adedara *et al.*, 2023), there is an eminent increase in the rate of waste produced in Municipalities between 2012 and 2016, increasing from 81 million tonnes to 174 million tonnes (Adedara *et al.*, 2023) per year and is projected to increase to 269 million tonnes (Adedara *et al.*, 2023) in 2030. This suggests that the amount of waste generated surpasses the rate of sustainable SWM in SSA posing serious environmental and health problems. This sub-region is characterized by low technological advancement in waste recycling and recovery as most of the waste can be seen dumped in landfill areas. The negative consequences of improper SWM in SSA rest on the underprivileged in society who have little, or no knowledge of the waste being disposed of formally or informally (Kaza *et al.*, 2018) around residential areas. Therefore, sustainable waste management in SSA is of primary importance to ameliorating these health and environmental challenges and hence ensuring a good habitable environment for human well-being.

Cameroon is a country located in SSA with an estimated population of 26.5 million in 2020 (Enjema, *et al.*, 2020), and an annual growth rate of 2.6% (INS, 2019) and is projected to reach

50 million by 2050 (UN, 2014). In Cameroon, 50% (Parrot *et al.*, 2009) of the people are in the urban areas. Statistics indicate an increase in urban population from 28.5% of the total population to 52.8% (Sotamenou, 2018) between 1976 and 2003, and is anticipated to reach over 70% (INS, 2004, 2008) of the population by 2030 (Parrot *et al.*, 2009). This population growth rate has led to an urban growth rate of 3.63% (Chiatii and Aloysius, 2021), while 56.37% (Enjema, *et al.*, 2020) of the population are presently residing in urban areas as against 39% (Parrot *et al.*, 2009) in the 1990s. The urban growth rate in Cameroon is influenced by factors such as a high rural-urban migration (Wantim, 2023), and an increase in commercial and industrial activities, resulting in a high rate of waste generation. In Cameroon, Law No. 96/12 of 5 August 1996 (Naseri, 2021), lays down the guiding principles on environmental protection, facilitated by Decree No. 2011/2584/PM of 23 August 2011 (Tamasang *et al.*, 2021), provides the norms for the protection of the soil and subsoil (Albrecht *et al.*, 2022). With the provisions of this law, its effective implementation (Tamasang *et al.*, 2021), is yet to be realized as many urban dwellers still dispose of waste along major streets and streams within Municipalities. It is therefore important to enforce the proper implementation of the law to ensure a sustainable social and economic environment for human well-being (Warlia *et al.*, 2023).

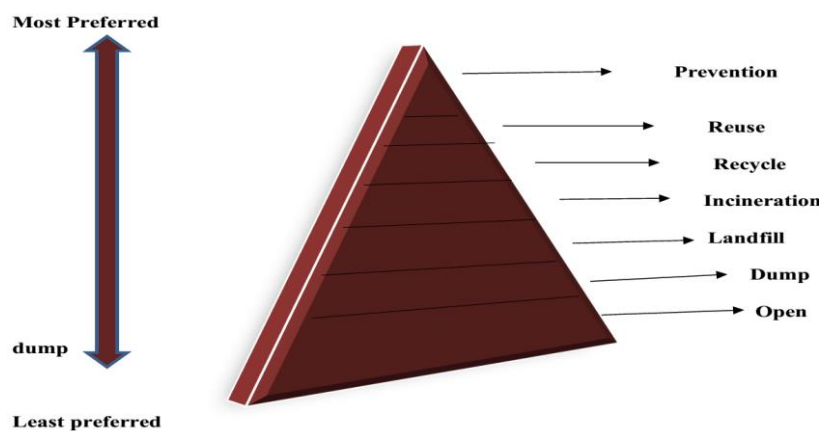
Cameroon produces an estimated 6 million tons (McKay *et al.*, 2015), of MSW in a year, making solid waste an important environmental and health problem (Palouma, 2013). The Bamenda III Municipality of the Northwest Region of Cameroon has witnessed an increase in its build-up area (Akei and Babilia, 2022), signalling an increase in its urban population growth rate in the past 20 years (Ndikebeng *et al.*, 2023). The Municipality is experiencing exponential growth in waste production due to; the inability of the City/Municipal Council Authorities to timely manage solid waste, in frequent lockdowns of the Municipality by separatist fighters since the start of the crisis that has affected the two English-speaking regions of the country (Harrison, 2024) since November 2016, inadequate infrastructure for waste management, population growth and economic development (Wanie *et al.*, 2021). So far, little effort has been directed towards careful analysis of these challenges with SWM in the Municipality. Several studies (Kien, 2018, Samba, and Kuma, 2020, Wanie *et al.*, 2021), have been carried out in Bamenda Metropolis relating to waste management. These authors did not address the challenges and measures to improve waste management in the Municipality. Studies on SWM in Bamenda III Municipality are extremely limited. Prompt action is needed in this sector to foster progress in sustainability (Ages, 2017) in waste management, and following Sustainable Development Goals (SDG) 3 and 11 (Łęcka and de Kuyper, 2023). The relevance of the integrated sustainable waste management approach in this study is that it takes into consideration a balance of environmental, health, institutional, technical, social and financial (Aparcana, 2017), and legal issues on waste management in a Municipality (Fatimah *et al.*, 2020) to provide sustainability to the system. The study aims to generate empirical knowledge on an important aspect of MSW by identifying the

key drivers of inadequate waste management in an African Municipality. Secondly, it goes beyond identifying these drivers to suggesting measures that can enhance sustainable waste management in a Cameroonian Municipality. This article proceeds with a presentation of the theoretical framework and research method, the results and discussion of findings and lastly the conclusion.

**1.2. Theoretical Framework**

This study hinges on the Integrated sustainable waste management (ISWM) approach which is one of the most conventionally (Abdoli, 2016) accepted approaches for MSWM, and allows for deeper insight into the complex and multi-dimensional (Iacovidou *et al.*, 2017), waste management system (Millward-Hopkins *et al.*, 2018) in an integrative manner (WASTE, 2004). Integrated sustainable waste management (Al-Salem *et al.*, 2009) focuses on sorting waste and the use of proper techniques, technologies and management programs (Ikhlayel, 2018) to attain set goals and objectives of waste management in a municipality. The ISWM hierarchy (Awino and Apitz, 2024) (Figure 1) depicts the shape of a triangle with a well-arranged set of actions (Srivastava *et al.*, 2015) in which high advantages concerning the cost of input, adequate utilization of resources (Abdifatah, 2021), greater recovery of reusables waste and recyclables (Chandrappa and Das, 2024), environmental compliance and health concerns (Muiruri, 2022), and socially appropriate are achieved. Three major components of ISWM, which are related to each other, are stakeholders, waste system elements and sustainability aspect (van de Klundert and Anshu'tz, 2001). So, there is a need to design an ISWM system in the Bamenda III Municipality in such a way that it will help mitigate the negative consequences of improper waste management in a sustainable manner.

**Figure 1: Waste Management Hierarchy**



Sources: Adapted from Achankeng (2004)

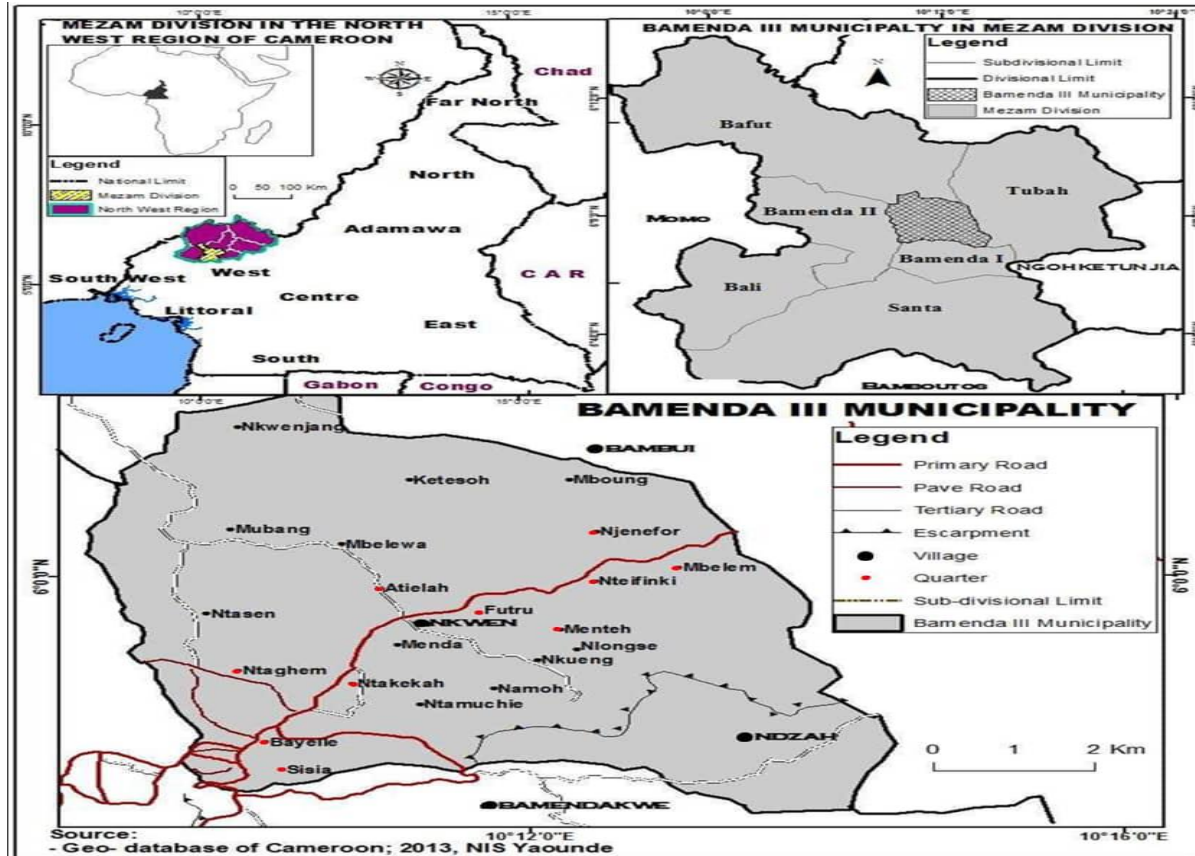
Waste management is about all the opportunities put in place in a Municipality, regarding waste management in a sustainable manner, without tampering with other aspects of human life and well-being. The waste management hierarchy shows the classification of waste management options descending from top to bottom. Integrating this approach to waste management in Bamenda III Municipality, the most valuable resources could be removed from waste while producing less waste in the Municipality (Nanje, 2021). Sensitizing the residents of Bamenda III Municipality on appropriate measures to limit the production of waste is of primary importance. Therefore, waste prioritization in the Municipality will enable residents to sort reusable waste from non-reusable waste.

## **2. Research Method**

### **2.1 Study Area**

The study was carried out in the Bamenda III Municipality (figure 1) in the Mezam Division. The Municipality is situated between latitudes 6°15 and 6°25N and Longitudes 10°02 and 10°15E (Ndikebeng *et al.*, 2023), of Green which Meridian. It shares a common boundary with Tubah Municipal to the West, Bamenda I Municipal to the North, Bamenda II Municipal to the East, and Bafut Municipal to the South (Ndikebeng *et al.*, 2023). The Municipality is cosmopolitan (Wanie *et al.*, 2021), coupled with the creation of many lay private and public higher educational institutions with high population density which makes it suitable for this study. The population of Bamenda III Municipality is increasing because of a very high migration rate (Mbanga, 2018). It covers a total surface area of 67.9 km<sup>2</sup> (Mbanga, 2018) and a population estimated at 150,000 inhabitants (Tume *et al.*, 2020) with a 6% increase per annum (Bamenda III Council, 2012). Two autonomous villages, Nkwen and Ndzah (Bamenda III Council, 2012), make up the Bamenda III Municipality with 46 quarters in Nkwen and 9 in Ndzah village respectively. Nkwen village was purposively selected for this study because it is one out of the seven villages (Wanie, 2019), that make up the Bamenda City Council Area with a high population density of 1,584/km<sup>2</sup> (Bamenda III Council, 2012), a high rate of urbanization with increase in infrastructural development from 12.28% in 2000 to 21.12% in 2020 (Akei and Babila, 2022), and subsequently, high rate of municipal waste generation compared to Ndzah which is at the peripheral area of the Municipality.

Figure 1: Bamenda III Municipality, Mezam Division, Northwest Region, Cameroon.



Source: Modified from Mbanga (2018).

## 2.2 Study Design

This study employed the quantitative research approach which has to do with the collection of numerical data from a study population and generalizing the results (Davies and Fisher, 2018), across the entire population. This approach was used to examine solid waste management in Bamenda III Municipality, Cameroon. A survey was conducted from April to July 2024 in the Municipality.

The study population comprised households in Nkwen, Bamenda III Municipality in the Mezam Division. Households who were residents of Ndzah village were not included in the sample because the village is more rural and sparsely populated, located on the outskirts of the Bamenda City Council Area.

A sample of 100 households was used. Nkwen was purposively selected due to its high population density resulting in a high generation of solid waste in the Municipality. Systematic sampling was used to select the participants comprised of household heads, businessmen, tenants, students, civil servants, and youths of the active age group who were administered questionnaires. This was achieved by first identifying all the quarters in Nkwen where the study was conducted. Ten (10) out of the forty-six (46) quarters were randomly selected (Sisia, Bayelle, Ntaghem, Ntakekah, Atielah, Futru, Nta-ifinki, Mbelem, Njenefor and Menteh). Sampling intervals were determined in the field with the assistance of the quarterhead of each of the quarters selected. Each quarter was divided into five wards and all households were identified. From the sample intervals, the researchers randomly selected 2 households from each ward, giving a total of 10 households until the required sample size was obtained.

Structured questionnaire and observation were used for the primary data collection. Several field visits were made in the area in the months of April-July 2024 to observe the real situation on the ground confronting the challenges in SWM in the Municipality and enriching the data collected with the use of questionnaires. Secondary data was obtained through the review of literature in academic journals, dissertations, theses (online), and books, published and unpublished materials. Descriptive statistical tools were used in analyzing data and the results were presented in charts, simple percentages, and frequency tables.

### **3. Results**

#### **Characteristics of Sample Population**

The results reveal that many study participants were females (68%) and males (32%). The findings indicate that most participants (42%) fall between the ages of 31-40 years. This was closely followed by those who fall within the ages 20-30 years (29%) and participants who fall within the ages 41-50 years (21%) while those who fall within the ages 51-60 years (8%). A greater proportion of the participants were married (42%), closely followed by those who were widows (17%). Single participants (15%) and those who were separated and divorced (6%) respectively, and widowers (4%). This implies that married homes produce more urban waste in the Municipality than single homes. Further analysis shows that many participants had GCE A/L (36%), closely followed by those with GCE O/L (23%). Participants who had a First School Leaving Certificate (FSLC) (21%), those with a bachelor's degree (13%), no formal education (4%), and those with a master's degree and above (3%). The results indicate that many of the participants (68%) were Christians. This is normal because this Municipality harbours more Christians than Muslims. This was followed by Muslims (30%), and those that were African Traditional Religious practitioners (2%). The findings indicate that most participants had a household size of 0-4 (38%), followed by those with a household size of 5-9 (35%), and

participants with a household size of 10 and above (7%). The findings reveal that most participants were traders (39%), followed by those who were farmers (32%), participants who were private sector employees (21%) and those who were civil servants (8%). The findings show that (37%) of participants have lived in the community for more than 10 years, followed by those who have lived for less than 10 years (36%), and participants who have lived for 20 years and above (27%).

**Types of Solid Waste in Bamenda III Municipality**

Table 1 shows that half of the participants (50%) strongly agree that organic waste is a type of waste. This was closely followed by participants who agreed (40%) and those who were undecided (10%). The results further prove that more than half (70%) of participants strongly agreed that plastics were another type of waste, those who agreed (25%), and participants who were undecided (5%). The results reveal that (38%) of participants disagree that inert material was not a type of waste, followed by those who strongly disagree (28%), participants who agree (23%), and those who strongly agree (17%). Many participants (60%) disagreed that paper and cardboard are not types of waste, participants who agreed (15%), those who strongly agreed and strongly disagreed (10%) respectively, and participants who were undecided (5%). The results indicate that (35%) of participants were undecided about whether miscellaneous materials were types of waste, followed by those who strongly disagree (27%), participants who strongly agree (23%), those who disagree (10%), and those who agree (5%). Many of the participants (42%) disagree that textiles are not types of waste, those who agree (38%), participants who strongly disagree (11%), and those who strongly agree (9%). The findings reveal that (44%) of participants disagree that metal is not a type of waste, participants who strongly disagree (28%), those who agree (12%), participants who were undecided (10%), and those who strongly agree (6%). Many participants (72%) disagree that glass is not a type of waste, participants who strongly disagree (12%), those who agree (11%), and participants who strongly disagree (5%). From the findings, many participants (23%) disagree that leather and rubber are not types of waste, those who agree (21%), participants who were undecided (15%), those who strongly agree (13%), and those who strongly disagree (10%).

**Table 1: Types of Urban Solid Waste**

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided	Total
Organics waste	50	40	0	0	10	100
	50%	40%	0%	0%	10%	
Plastics	70	25	0	0	5	100
	70%	25%	0%	0%	5%	
Inert materials	17	23	38	28	0	100
	17%	23%	38%	28%	0%	
Papers and cardboard	10	15	60	10	5	100
	10%	15%	60%	10%	5%	



Miscellaneous materials	23	5	10	27	35	100
	23%	5%	10%	27%	35%	
Textiles	9	38	42	11	0	100
	9%	38%	42%	11%	0%	
Metals	6	12	44	28	10	100
	6%	12%	44%	28%	10%	
Glasses	5	11	72	12	0	100
	5%	11%	72%	12%	0%	
Leather and rubber	13	21	23	10	15	100
	13%	21%	23%	10%	15%	

**Urban Waste Management Techniques in Bamenda III Municipality**

Table 2 shows that many participants (40%) agree that refuse-derived fuel (biogas) is a type of waste management technique in the Municipality. This was closely followed by those who disagreed (32%), Participants who strongly agreed (23%), those who strongly disagreed (15%), and participants who were undecided (5%). Many participants (33%) agree that sanitary landfill is a type of waste management technique, participants who disagree (21%), those who strongly agree (19%), participants who strongly disagree (18%), and those who were undecided (9%). The results show that most participants (31%) strongly agree that composting is a type of waste management technique. Those who disagreed (27%), participants who agreed (17%), those who strongly disagreed (16%), and those who were undecided (9%). The findings reveal that many participants disagree and strongly disagree that combustion was not a type of waste management technique (33%). This was closely followed by participants who agreed (23%) and those who strongly agreed (21%). Many participants (35%) agree that incineration is a type of waste management technique, followed by those who strongly agree (34%) those who disagree (12%) and those who strongly disagree (10%). More than half of the participants strongly agree that waste dumping is a type of waste management technique (63%), those who agree (21%), and participants who disagree (6%).

**Table 2: Types of Urban Waste Management Techniques**

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided	Total
Refuse-derived Fuel (Biogas)	23 23%	40 40%	32 32%	15 15%	5 5%	100
Sanitary landfill	19 19%	33 33%	21 21%	18 18%	9 9%	100
Composting	31 31%	17 17%	27 27%	16 16%	9 9%	100
Combustion	21 21%	23 23%	33 33%	33 33%	0 0%	100
Incineration	43 34%	35 35%	12 12%	10 10%	0 0%	100
Waste dumps	63 63%	21 21%	6 6%	0 0%	0 0%	100

### **Challenges in Waste Management in Bamenda III Municipality**

Table 3 indicates that most participants (31%) agree that the shortage of qualified engineers is a challenge in the Municipality, closely followed by those who strongly agree (25%), participants who disagree (22%) while those who strongly disagree (13%), and participants who were undecided (9%). The results reveal that many participants (41%) strongly agree that an increase in population is a challenge in waste management, followed by participants who agree (33%), participants who disagree (21%), and those who strongly disagree (5%). The findings indicate that most participants (41%) disagree that the area covered by waste management personnel is not a challenge in waste management, those who strongly agree (22%), participants who strongly disagreed (20%), and those who agree (17%). The results show that most participants (43%) agree that tenure of government is a challenge. This was followed by participants who agreed (29%), those who disagreed (12%), participants who strongly disagreed (10%), and those who were undecided (6%). The findings further that many participants (53%) agree that over-dependence on government authorities is another challenge in waste management in the Municipality. This was closely followed by those who strongly disagreed (23%), participants who agreed (17%) those who disagreed (11%), and those who were undecided (7%). Most participants (61%) strongly agree that finance and other factors of the environment are a challenge in waste management, those who agree (21%) participants disagree (10%), and those who strongly disagree (8%). Many participants (31%) strongly agree that the shortage of waste management personnel was a challenge in the Municipality, those who disagree (30%), participants who strongly disagree (23%) while those who agree (20%) and participants who were undecided (9%). The results indicate that many participants (30%) agree that the lack of effective legislation is a challenge in waste management, closely followed by those who disagree (28%). Participants strongly disagreed (21%) while those who strongly agreed (11%) and participants who were undecided (10%). Most participants (60%) strongly agree that limited equipment for waste management is a challenge, followed by participants who agree (11%), those who disagree (10%), and those who strongly disagree (9%). Many participants (31%) agree that the lack of community participation is a challenge. This was followed by participants who disagreed (30%) those who strongly agreed (22%), and participants who strongly disagreed (17%). The results reveal that more than half of the participants (66%) strongly agree that poor household waste segregation practice is a challenge in waste management. This was followed by participants who agreed (25%), and those who disagreed (17%). Most participants (42%) strongly agree that inappropriate trash canned for community waste management is a challenge, closely followed by participants who agree (37%), those who disagree (15%) while participants who strongly disagree (12%), and those who were undecided (6%).

**Table 3: Solid Waste Management Challenges**

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided	Total
Shortage of qualified engineers	25 25%	31 31%	22 22%	13 13%	9 9%	100
Increase in population	41 41%	33 33%	21 21%	5 5%	0 0%	100
Area covered	22 22%	17 17%	41 41%	20 20%	0 0%	100
Tenure of government	29 29%	43 43%	12 12%	10 10%	6 6%	100
Over-dependence on government authorities	53 53%	17 17%	11 11%	23 23%	7 7%	100
Finance and other factors of the environment	61 61%	21 21%	10 10%	8 8%	0 0%	100
Shortage of waste management personnel	31 31%	20 20%	30 30%	23 23%	9 9%	100
Lack of effective legislation	11 11%	30 30%	28 28%	21 21%	10 10%	100
Limited equipment	60 60%	11 11%	10 10%	9 9%	0 0%	100
Lack of community participation	22 22%	31 31%	30 30%	17 17%	0 0%	100
Poor household waste segregation practice	66 66%	25 25%	9 9%	0 0%	0 0%	100
Inappropriate setting of community trash canned	42 42%	37 37%	15 15%	12 12%	6 6%	100

**Measures to Improve Sustainable Waste Management**

Table 4 reveals that most participants (63%) strongly agree that massive sensitization is a measure that can improve waste management in Bamenda III Municipality. This finding suggests that the population of the Municipality should be sensitized especially to types of waste and management techniques to enhance sustainability in waste management. This was closely followed by those who agreed (23%), participants who were undecided (6%) those who disagreed (5%), and participants who strongly disagreed (3%). The results indicate that many participants (47%) agree that effective laws should be put in place to govern effective waste management. This suggests the view that sanctions should be implemented for defaulters by the law. This was followed by participants who strongly agreed (37%), those who were undecided (9%), and those who disagreed (7%). The findings show that (61%) of participants strongly agree that creating awareness of inhabitants on waste management is a measure. This supports the fact that the inhabitants of the Municipality are not aware of the types of waste management techniques in the Municipality. This was followed by participants who agreed (32%), those who were undecided (4%) and those who disagreed (3%). The findings show that most participants (41%) agree that the provision of incentives is a measure to improve waste management. This suggests that incentives should be instituted as a motivational factor in fostering sustainable waste management in the Municipality. This was followed by those who strongly agreed (35%),

participants who disagreed, those who were undecided (9%) respectively, and those who were undecided (6%). The results indicate that many participants (42%) disagree that financial policies are not measures to enhance the sustainability of waste management in the Municipality. This was followed by participants who agreed (23%), those who strongly agreed and strongly disagreed (12%) respectively, and those who were undecided (11%). The findings reveal that (61%) of participants strongly agree that providing waste management equipment is a measure to improve sustainable waste management, those who agree (33%), and participants were undecided (6%).

**Table 4: Measures to Improve on Sustainable Solid Waste Management**

Items	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided	Total
Massive sensitization	63	23	5	3	6	100
	63%	23%	5%	3%	6%	
Effective laws should be put in place	37	47	7	0	9	100
	37%	47%	7%	0%	9%	
Awareness creation	61	32	3	0	4	100
	61%	32%	3%	0%	4%	
Provision of incentives	35	41	9	9	6	100
	35%	41%	9%	9%	6%	
Financial Policies	12	23	42	12	11	100
	12%	23%	42%	12%	11%	
Providing waste management equipment	61	33	0	0	6	100
	61%	33%	0%	0%	6%	

**4. Discussion**

The results reveal that many participants were females (68%) and males (32%). This suggests that women are the highest household waste producers in the Municipality of Bamenda III. The findings are in line with that of Agwu (2012) who showed that there is a difference in the predisposing factors on waste management practices by socioeconomic characteristics (sex, social class, and age) (Agwu, 2012) of inhabitants in Port-Harcourt City, Nigeria. Most participants were married (42%), suggesting the reason for the high rate of waste generated in the Municipality as married homes will normally produce more waste than single-parent homes.

Further analysis of the findings shows that most participants had GCE A/L (36%). This implies that many participants were educated and should have some knowledge of the environmental and health hazards of improper waste management in the Municipality. Many of the participants had a household size of 0-4 (38%). This implies that on average households in the Municipality are large and will probably produce large quantities of waste.

The results on types of solid waste in Bamenda III Municipality show that organic waste and plastics were the most common types of waste in the area. This implies that with large household sizes, many organic waste materials are being generated from homes and the inhabitants are still making use of plastic materials in the area irrespective of government decision forbidding the use of non-biodegradable plastic materials. In 2012, the government of Cameroon banned the use of plastic packaging on the grounds it clogs waterways, spoils the landscape, and takes a thousand years to break down (Kien, 2018). The findings of this study agree with that of Olukanni and Mnenga (2015), who identified other components of solid waste consisting of biodegradable materials (38.49%) while non-biodegradable (61.51%) (Olukanni and Mnenga, 2015) in Ota, Nigeria. The findings are also like those of Noor *et al.* (2020) who identified several types of waste and sources including liquid waste, solid waste, plastic waste, paper waste, tins and metals, ceramics and glass, organic waste, recyclable waste, non-degradable waste, hazardous waste, non-hazardous waste, radioactive waste, sanitary waste, construction, and demolition waste (Noor *et al.*, 2020). The results differ from that of Liu *et al.*, (2015) who found that in Beijing, China, the main categories of waste produced are wastepaper (24.4%), waste glass bottles (23.7%), and waste furniture (14.3%) (Liu *et al.*, 2015).

Results on techniques of waste management in Bamenda III Municipality show that refuse-derived fuel (biogas), sanitary landfill, composting, incineration, and waste dumps were types of SWM techniques in the Municipality. The results of this study differed from those of Muhammad *et al.* (2021) who found that in Nigeria, incineration, composting, sanitary landfills, and anaerobic digestion (Muhammad *et al.*, 2021) were the best waste management techniques. Composting has proven to be the most effective technique of waste management in their study whereas waste dumps have proven to be the most effective in the Bamenda III Municipality. The results also differed from that of Nanda and Berruti (2021) who identified waste recycling, incineration, waste-to-energy conversion, composting, or landfilling (Nanda and Berruti, 2021) as waste management techniques. As a result of their study, landfilling (Nanda and Berruti, 2021) for solid waste disposal is preferred in many Municipalities generally, whereas waste dumps proved to be the most effective technique in the Bamenda III Municipality. Landfill sites act as areas for waste to undergo physical, chemical, and biological transformations (Nanda and Berruti, 2021).

The findings on the challenges in waste management revealed that a shortage of qualified engineers, increase in population, terms of governance, over-reliance on government authorities for waste management, inadequate finances in waste management, environmental conditions, shortage of waste management personnel, non-implementation of the legislation on effective waste management, inadequate equipment for proper waste management, non-involvement of community members in waste management, poor household waste segregation practices and inappropriate setting of community trash canned were the major challenges in the Bamenda III Municipality. The findings are like that of Ike, *et al.* (2018), who identified challenges to include poor collection and disposal methods, lack of a waste management information system, insufficient financial resources, non-adherence to laws and lack of knowledge of the consequences of improper sanitary habits (Ike, *et al.*, 2018) in Nigeria.

From findings on measures to improve waste management in Bamenda III Municipality, massive sensitization, effective laws, awareness creation, and the provision of incentives and waste management equipment are measures to improve sustainable waste management in the Municipality. The findings differ from that of Uwadiogwu, and Chukwu, (2013) who suggested mobilizing the citizens and educating them on the negative consequences of improper waste management, building the capacity of public agencies, a devoted government, logistics and infrastructural advancement, the law, proper technologies, monitoring, and control are effective strategies for solid waste management in Nigeria (Uwadiogwu, and Chukwu, 2013). Appropriately prioritizing all these measures and considering the importance of the waste management hierarchy will lead to sustainability in waste management in the Bamenda III Municipality.

## **5. Conclusion**

Sustainability challenges in waste management in Bamenda III Municipality have attracted the attention of scholars, government officials, politicians, civil society organizations, and stakeholders to talk about. Two major types of waste were identified; organic waste (biodegradable) and plastics (non-biodegradable) were the most common types of waste in the municipality. Refuse-derived fuel (biogas), sanitary landfills, composting, incineration, and waste dumps were types of waste management techniques. Waste dumping was identified as the most effective way of managing waste in the Municipality, which is very unsustainable. Challenges such as shortage of qualified engineers in waste management, increase in population, term of governance, over-reliance on government authorities in waste management, inadequate finances and other environmental conditions, shortage of waste management personnel, lack of the implementation of effective legislation, limited waste management equipment, the non-participation of community members in waste management, poor household waste segregation practices, and inappropriate setting of community trash canned were identified in Bamenda III

Municipality. To conclude, massive sensitization of the inhabitants of the Municipality, effective implementation of laws on waste management by the governing, awareness creation, provision of incentives as a motivational approach to sustainable waste management, and provision of waste management equipment are some of the measures to improve sustainable waste management in the Municipality.

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